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Habitat Biodiversity as a Determinant of Fish Community Structure on Coral Reefs in Halang Melingkau Island, Kotabaru, South Kalimantan, Indonesia

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ABSTRACT

The ecosystem of coral reefs is a fundamental process for marine resources playing an important role in supporting the lives of various aquatic organisms, with coral reef fish being one of the main dependent sea animals. The current study was purposely undertaken to assess coral reef fish biodiversity and its association with coral coverage on Halang Melingkau Island, Kotabaru, South Kalimantan, Indonesia. This research was conducted in April 2019 on Halang Melingkau Island, Kotabaru, South Kalimantan, Indonesia. The research was carried out at 6 stations with 18 observation points that were considered to be representative of the conditions of coral reefs and coral reef fish in the waters of the island. The field observation method was applied by laying down 50-meter line transects (line intercept transects) and using visual census (underwater visual census) to obtain data concerning fish and coral populations. The findings indicated that the average coral reef coverage in Halang Melingkau Island was moderate (33.77%) , and it was remarkable that station 6 had the best coral reef coverage (53.71%) . Additionally, station 6 possessed the highest fish population as well as the highest number of fish species. Findings of the present study predict that correlation analysis indicated a strong positive correlation between coral coverage and the abundance of coral reef fish. In this essence, when the coral coverage increases, the coral reef fish abundance would also increase. Simultaneously, a decrease in the coral reef coverage in a specific location could result in the decrease in the abundance of coral reef fish

INTRODUCTION

The coral reef ecosystem is an important part of the marine ecosystem, and coral reefs are a source of life for more than 500 species of marine life. The coral reef ecosystem comprises more than 300 types of corals, 200 species of fish, and dozens of species of mollusks, crustaceans, sponges, algae, and others biota **(Dahuri, 2000)**. One of the main fish species found in coral reef ecosystem include coral reef fish, which live in association with corals and have the highest population of all the fish species in this ecosystem. Juvenile as well as adult reef fish are found in corals and, therefore, any damage or destruction of the coral habitat would directly affect the diversity of coral reef fish.

Coral reef fish is a sea animal that can be found in numerous habitats in the coral reef area, and coral reef damage seriously impacts the abundance, density, and diversity of this fish species. Importantly, habitat diversity is a primary factor that affects the number of fish species and their populations in the coral reef system **(Luckhurst & Luckhurst, 1978)**. Thus, the diversity of coral reef fish is closely associated with the complexity of the coral reef surface. Various species of coral reef fish inhabit the narrow ecological niches provided by the coral reef. This results in the coral reef fish being localized only to particular areas of the coral reef **(Ilham, 2007)**, but several reports have shown that fish abundance is also associated with coral reef complexity **(Hixon & Beets, 1989; Friedlander & Parrish, 1998; Gratwicke & Speight, 2005; Chong-Seng *et al*., 2012; Bozec *et al*., 2013)**.

Kotabaru Regency is one of the 11 regencies in South Kalimantan Province in Indonesia. Geographically, Kotabaru Regency is located from -3.167 and 115.417 to -4.333 and 116.333. The total area of Kotabaru Regency is 9.422,46 km^2, and it comprises 25.21% of the area of South Kalimantan Province. Kotabaru Regency mainly comprises one large island and 140 small islands **(McElroy, 2006)**. Halang Melingkau Island is part of a marine nature park according to Kotabaru Regional Regulation No. 11 of 2012 concerning spatial planning for Kotabaru Regency in 2012–2032. This regulation is in accordance with provisions for the marine nature park in South Kalimantan Province Regional Regulation No. 9 of the Republic of Indonesia of 2015 concerning the regional spatial planning of South Kalimantan Province in 2015–2035.

Coastal areas acquire the highest productivity and owe various benefits, one of which is the many species of fish and coral that live in coastal waters. However, coastal waters are the most vulnerable and are potentially under pressure from threats posed by land and sea. In their study, **Munasik and Siringoringo (2011)**, assessed that the coral community in South Kalimantan is unstable and has encountered a drop because of the effect of land run-off originating from the Barito River. To examine this phenomenon, the present study aimed to determine the biodiversity of coral reefs based on the condition of the coral cover on Halang Melingkau Island, Kotabaru Regency, South Kalimantan, in Indonesia.

MATERIALS AND METHODS

This study was conducted in April 2019 on Halang Melingkau Island, Kotabaru, South Kalimantan, Indonesia. The research was achieved on six stations with eighteen observation points that were considered to represent the condition of coral reefs and reef fish in the waters of the island. The stations and observation points were selected in such a way that the various regions of Halang Melingkau Island were proportionately covered. **Fig. 1** provides an overview of one of the observation points. **Table 1** presents the coordinates of the observation sites.

Table 1. Coordinates of the observation points

Stations		Coordinates		Depth (m)	Observation Method
	1.1	-3.657	116.613	1 - 2	Snorkling
1	1.2	-3.658	116.614	1 - 2	Snorkling
	1.3	-3.658	116.613	6 - 8	Diving
	2.1	-3.655	116.614	1 - 2	Snorkling
2	2.2	-3.654	116.614	1 - 3	Snorkling
	2.3	-3.654	116.613	7 - 9	Diving
	3.1	-3.654	116.616	1 - 2	Snorkling
3	3.2	-3.654	116.617	2 - 3	Snorkling
	3.3	-3.653	116.617	7 - 8	Diving
	4.1	-3.656	116.616	1 - 2	Snorkling
4	4.2	-3.655	116.617	1 - 3	Snorkling
	4.3	-3.656	116.617	6 - 7	Diving
	5.1	-3.658	116.616	1 - 2	Snorkling
5	5.2	-3.658	116.615	2 - 3	Snorkling
	5.3	-3.659	116.615	6 - 8	Diving
	6.1	-3.656	116.618	10 - 11	Diving
6	6.2	-3.657	116.617	8 - 10	Diving
	6.3	-3.659	116.615	10 - 11	Diving

1. Data Collection Method

Coral reef data were collected using the line intercept transect method of **English *et al*. (1997)**. First, a 50 m transect line was laid parallel to and along the coastline, as close to the substrate as possible. The observers waited at the starting point for about five minutes after the transect line was laid to gain a general picture of the reef fish present at the observation site so as to give the fish time to return to normal behavior after the disturbance caused by the laying of the transect. Next, fish species were observed within a distance of 2.5 m to the left and right of the transect line and were then recorded on a slate. Based on the UVC method, special characteristics of the fish bodies (i.e., mouth shape, body shape, fins, and color) were directly recorded by one observer through drawing on a waterproof paper, while another observer documented the fish traits using a camera (in the form of photos or videos).

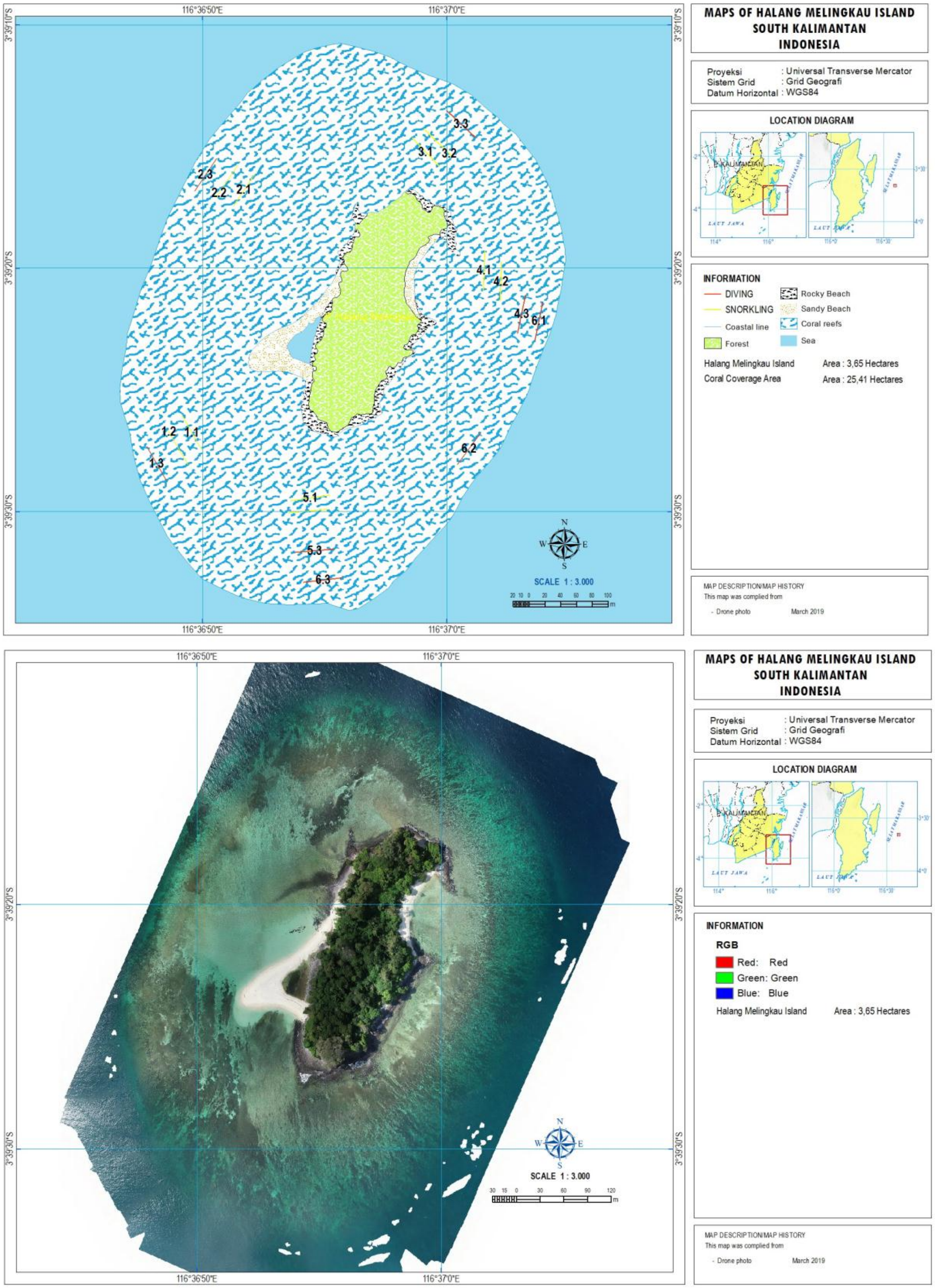


Fig. 1. Research Location Map of Halang Melingkau Island, Kotabaru, South Kalimantan - Indonesia.

The transect was also recorded using an underwater camera that had been set to video mode. Fish abundance was calculated over a monitoring distance of 2.5 m to the left and right of the transect for fish with size less than 35 cm and a distance of 5 m to the left and right for fish measuring ≥35 cm. Coral reef fish species that could not be directly identified by the observers were briefly described on the slate and/or photographed. Those fish were then identified using the identification key provided by **Kuiter (1992)**. Fish and coral data were collected sequentially. After the fish data were collected, there was an interval of a few minutes before coral data collection got started **(Levinton, 2013).** Observations were revealed by recording the forms of coral growth (lifeforms) and abiotic components that alluded to the transect. Additionally, the growth lifeforms were measured using the measurement indicators on the line.

Coral reef fish data were obtained using the underwater visual census (UVC) method **(English *et al.*, 1994)**. This method is used globally to survey shallow water environments and is primarily used to make decisions about temperate reefs and coral reefs in conservation and fisheries management **(Pais & Cabral, 2018)**. The starting point of transect installation was along the coastline using a 50 metre roll, in a site as close as possible to the substrate. The forms of coral growth (lifeform) and the abiotic component that alluded to transects were observed and recorded. Meanwhile, measuring the range of closure of growth forms on the numbers read on the metre roll was determined

2. Data Analysis

2.1 Percentage of Coral Reef Coverage

The percentage of coral reef coverage was calculated with the following formula **(English *et al*., 1997)** :

$$C = \frac{\alpha}{A} \times 100\%$$

Description:

C = percentage coverage of lifeform i (%)

A = transect length of lifeform i (in meters)

A = Total transect length (in meters)

According to **Gomex and Yap (1988)** and the **Minister of Environment of the Republic of Indonesia (2001)**, four criteria were used to evaluate the coral reef, as shown in **Table 2**.

Table 2. Criteria of coral reef cover percentage based on Decree of the Minister of Environment of the Republic of Indonesia No. 4 of 2001

% cover	Category
75 - 100	Excellent
50 – 74.9	Good
25 – 49.9	Fair
0 – 24.9	Poor

2.2 Community Structure of Coral Reef Fish

The following indexes were used to assess the community structure of coral reef fish.

- **Shannon Wiener Diversity Indeks (H')**

$$H' = \sum_{i=1}^{s} \quad pi\ ln\ lnpi$$

Description:

H' = Shannon Wiener diversity index.
s = number of coral reef fish species.
pi = population of each coral reef fish species

Based on the Shannon Wiener diversity index, the coral reef fish diversity is assessed according to the criteria of **Brower and Zar (1977)**:

- H' ≤ 2.30 : diversity is low and is indicative of very strong environmental pressure.
- 2.30 <H' ≤ 3.30 : diversity is moderate and is indicative of moderate environmental pressure.
- H'> 3.30 : diversity is high and is indicative of ecosystem balance

- **Homogeneity index (E)**

$$E = \frac{H'}{Hmax}$$

Description:

E = homogeneity index
Hmax = maximum species balance

This index is used to assess homogeneity based on the criteria of **Brower and Zar (1977)**:

- E ≤ 0.4 : homogeneity is small and is indicative of a depressed community
- 0.4 < E ≤ 0.6 : homogeneity is moderate and indicative of an unstable community
- E > 0.6 : homogeneity is high and is indicative of a stable community

- **Dominance Index (C)**

$$C = \sum_{i=1}^{s} \quad pi^2$$

Description:

C = Dominance index
pi = Population of individual coral reef fish species
s = Number of coral reef fish species

The dominance index value ranges from 0 to 1: if the value approaches 1, there is a tendency for one species to dominate over the other.

3. Correlation between Coral Cover and the number of Coral Reef Fish

The correlation of the percentage of coral reef coverage with the abundance of coral reef fish was assessed using the linear regression method with Microsoft Excel 2016. Linear regression analysis is used to measure the strength of the correlation between two or more variables and predict the estimated Y value (the number of coral reef fish) based on the X value (coral reef coverage). As proposed by **Kutner *et al*. (2004)**, the following linear regression equation was used.

$$y = a + bx$$

Description:

y	= Dependent variable	b	= Regression coefficient
a	= Constant	x	= Independent variable

RESULTS

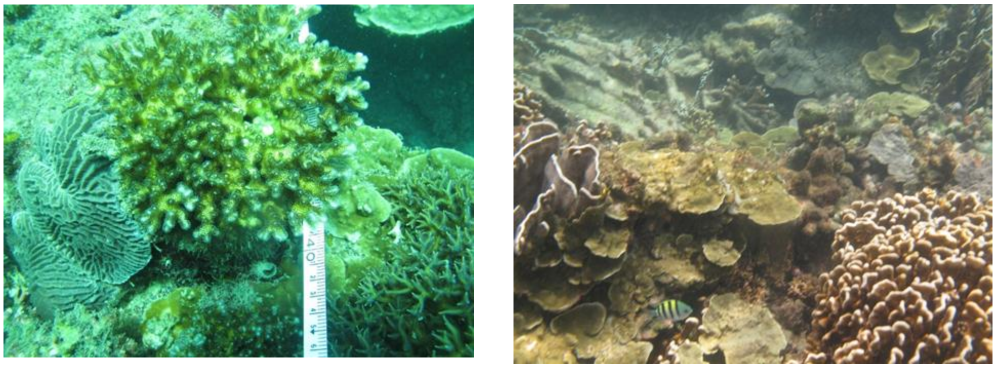
1. Biodiversity Habitat

Hard coral cover at each station showed different values: the highest value was measured at station 6 while the lowest, at station 2. The average hard coral coverage on Halang Melingkau Island was 33.77 ± 19.13%, which is considered a moderate coverage. Detailed information about coral reef coverage at each station is shown in **Table 2**. The coral reef conditions of each station are presented in **Fig. 2**.

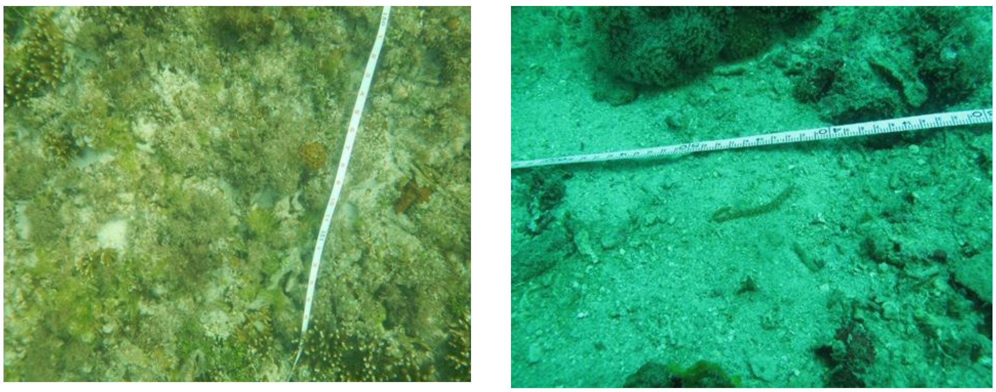
Tabel 2. Percentage of hard coral coverage at each station

Station	Hard coral coverage (%)	Categories based on Decree of the Minister of Environment of the Republic of Indonesia No. 4 of 2001
1	49.89 ± 13.01	Fair
2	1.43 ± 0.86	Damage
3	23.53 ± 5.41	Damage
4	37.37 ± 14.88	Fair
5	36.67 ± 21.67	Fair
6	53.71 ± 10.62	Good

As shown in **Table 2**, station 6 had the best coral cover, while stations 2 and 3 had the poorest coral cover. This indicates that the environmental conditions at Station 6 were favorable for coral growth. As seen in the images in **Fig. 2**, station 6 has good coral cover, while the rubble of coral fragments can be seen in the images for station 2.

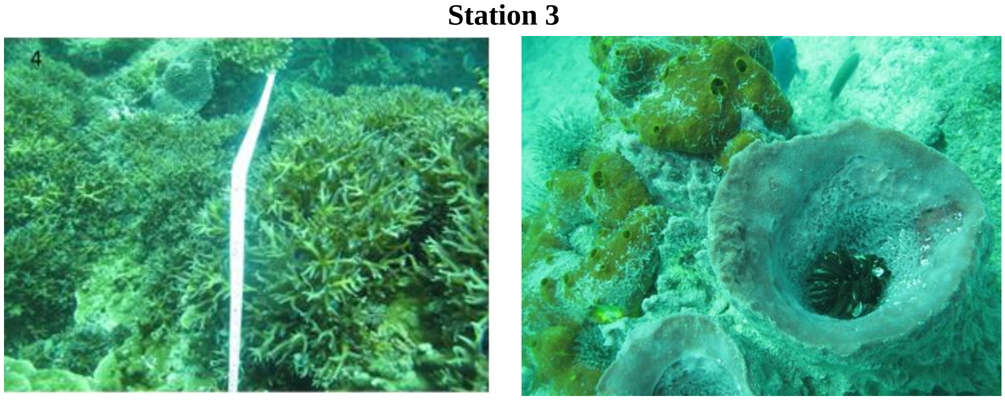


Station 1



Station 2

Station 3



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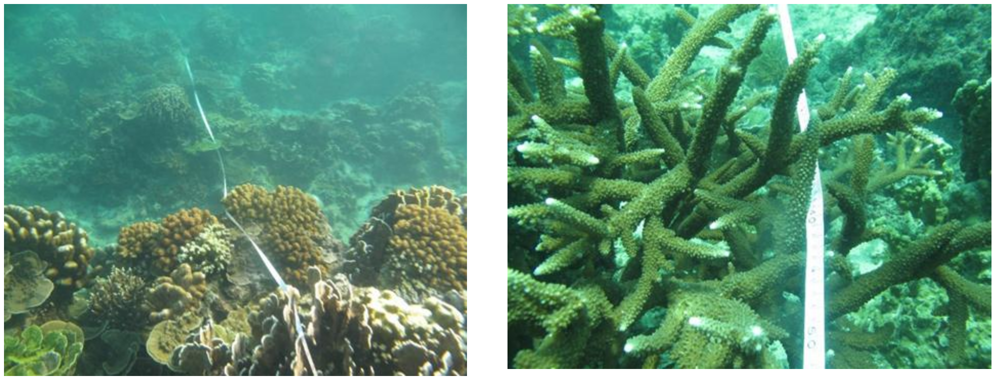
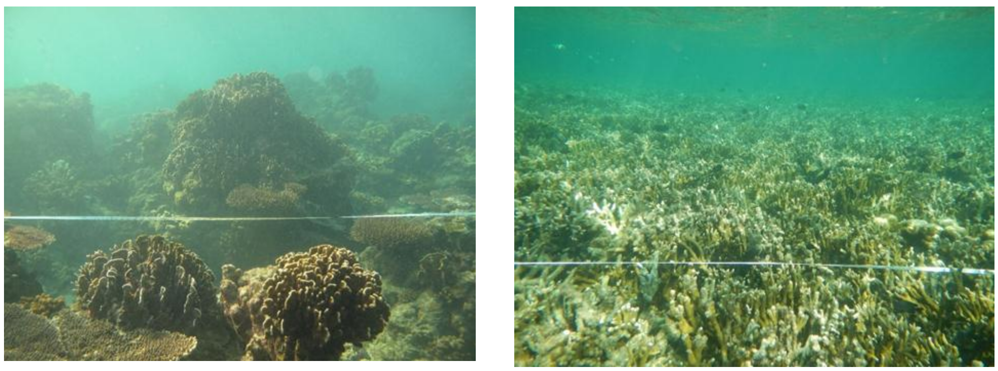


Station 5



Station 6

Fig. 2. Coral reef conditions on six stations observed on Halang Melingkau Island, South Kalimantan, Indonesia

The results of hard coral coverage positively correlate with the number of fish observed at station 6. The coral substrate can be categorized as live substrate (biotic) and dead substrate (abiotic) based on its characteristics. The living substrate category comprised hard coral (HC), dead coral with algae (DC), soft coral (SC), algae (AL), sponge (SP), zoanthids (ZO), and other fauna (OT), while the non-living substrate included sand (S), rubble (RB), and rock (RC). The biotic and abiotic coverage at each station is presented in **Fig. 3**.

Fig. 3 shows that hard coral dominated the living substrate (biotic) at station 6. In addition, sponges (8.33%), soft corals (0.13%), and other fauna (1.80%) also contributed to the living substrate. The non-living (abiotic) substrate at station 6 was dominated by coral fragments (10.60%) and sand (2.63%). **Fig. 3** also shows that station 2 (94.53%) and station 3 (52.43%) were largely comprised of the rubble of coral fragments. This is indicative of damage to the coral reef in the corresponding areas.

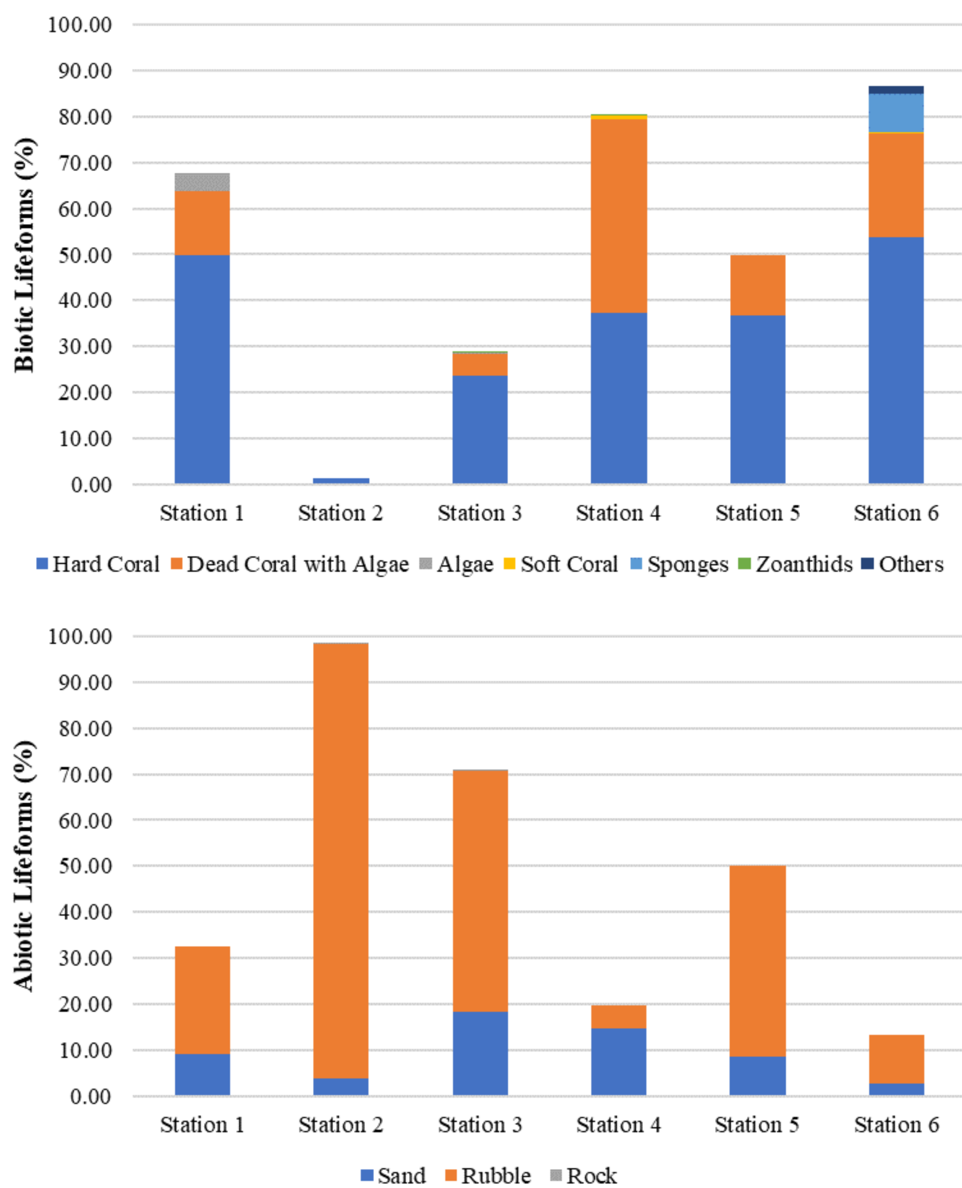


Fig. 3. Biotic and abiotic coverage on Halang Melingkau Island, South Kalimantan, Indonesia

At the observation site, coral growth in terms of *Acropora* species was found in two forms: *Acropora* branching (ACB) and *Acropora* tabulate (ACT). Further, non-*Acropora* corals were found in four lifeforms: coral branching (CB), coral encrusting (CE), coral foliose (CF), and coral massive (CM) (**Fig. 4**). **Fig. 4** also shows variations in the composition of coral lifeforms in the six research stations. The coral coverage at stations 4, 5, and 6 was dominated by non-*Acropora* species of hard corals in the CM lifeform. ACB and ACT corals from the *Acropora* group were found to be dominant at stations 1 and 6. Additionally, stations 1 and 6 had a higher variation in growth lifeform composition than stations 2 and 3.

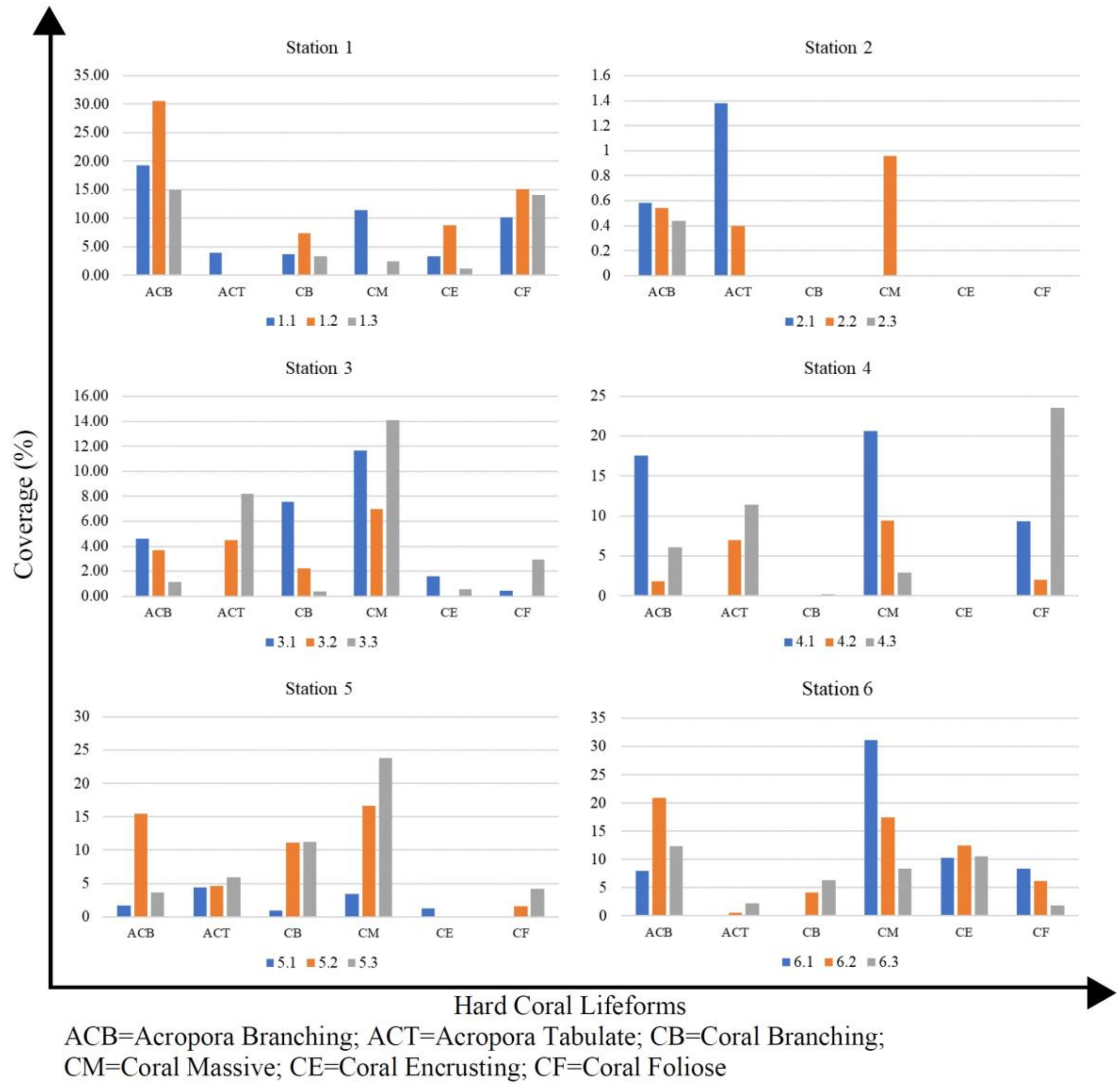


Fig. 4. Composition of hard coral lifeforms on Halang Melingkau Island, South Kalimantan, Indonesia

2. *Coral Reef Fish*

The observations showed that the Pomacentridae family contributed the highest number of species (biodiversity) (34 species), while Labridae and Chaetodontidae contributed 10 species each. Furthermore, there were 1788 individuals from the Pomacentridae family, and 356 and 233 individuals from Labridae and Chaetodontidae, respectively. The composition of each coral reef fish family is depicted in **Fig. 5**.

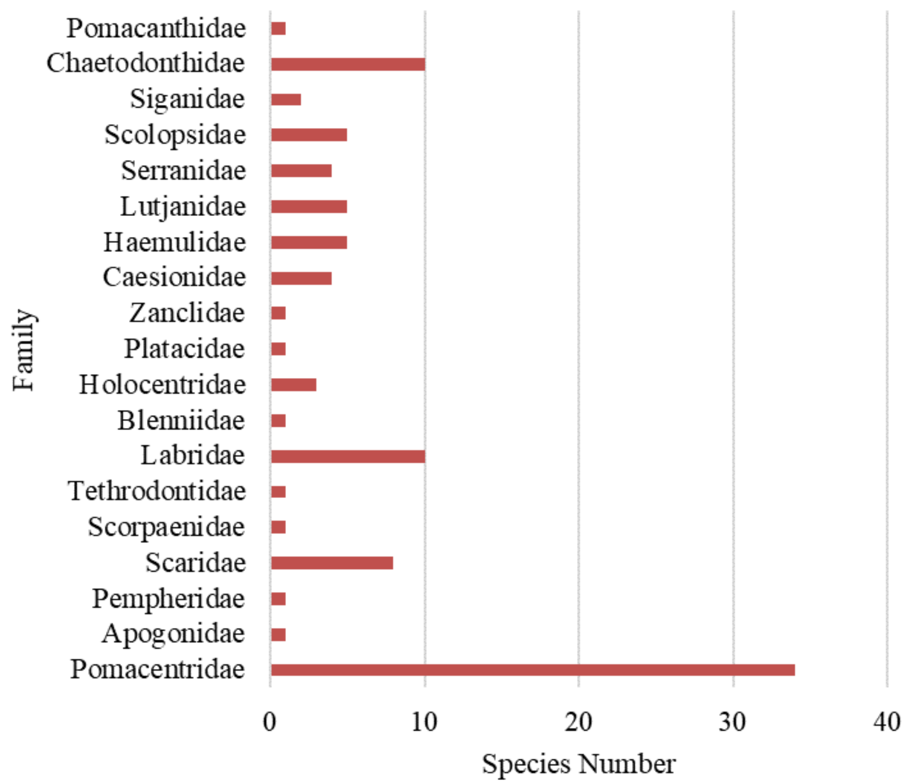


Fig. 5. Families of the coral reef fish species on Halang Melingkau Island, South Kalimantan, Indonesia

Fig. 6 shows that the number of reef fish (in the major, target, and indicator categories) at station 6 was higher than that at the other stations. Station 6 had the highest number of fish (729 individuals) of the major category. It was followed by station 1 (645 individuals), while station 2 had the lowest number (92 individuals) of fish in the major category. With regard to the target fish category, the highest number of individuals was found at station 6 (579 individuals). It was followed by station 3 (344 individuals), while station 2 had the lowest number of fish (1 individual) in the target category. With regard to indicator fish, station 6 had the highest number (100 individuals) followed by station 1 (62 individuals). Station 3 had the lowest number of indicator fish (6 individuals).

Fig. 6 also shows the variation in the number of coral reef fish species at each station: the highest number of species was found at station 6 (major fish: 32 species, target fish: 11 species, and indicator fish: 9 species). In contrast with station 6, station 2 had the lowest number of species (major fish: 8 species, target fish and indicator fish: 1 species, each), and station 3 had the lowest number of indicator fish species (n = 1). The diversity index (H′), homogeneity index (E), and dominance index (C) of coral reef fish at each station are shown in **Fig. 7**.

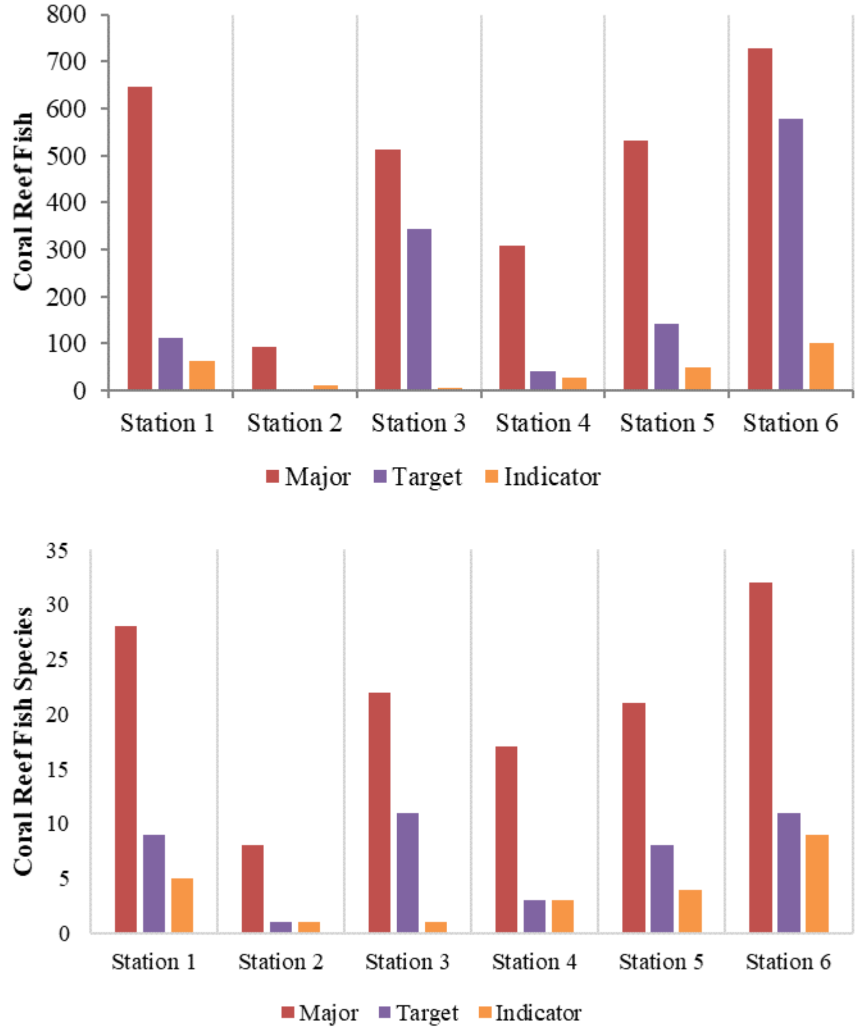


Fig. 6. Total number of coral reef fish and the number of individual species at each station

Fig. 7 shows that the highest diversity index (3.53) was found at station 1: this indicates ecosystem balance at this location without the dominance of one species of fish. Stations 3 to 6 also showed fairly high diversity index values ranging from 2.83 to 3.30. Similarly, the homogeneity index and dominance index also recorded varied values in the range of 0.72–0.94 and 0.03–0.13, respectively.

3. Correlation of the number of Coral Reef Fish with Coral Reef Coverage Percentage

The coral reef cover percentage significantly impacted the number of coral reef fish ($P<0.05$, $R^2=0.5796$). The number of coral reef fish tended to increase as the percentage of coral reef cover increased, as indicated by the linear regression equation "y=17.821x + 116.73" and r-value of 0.761 **(Fig. 8)**.

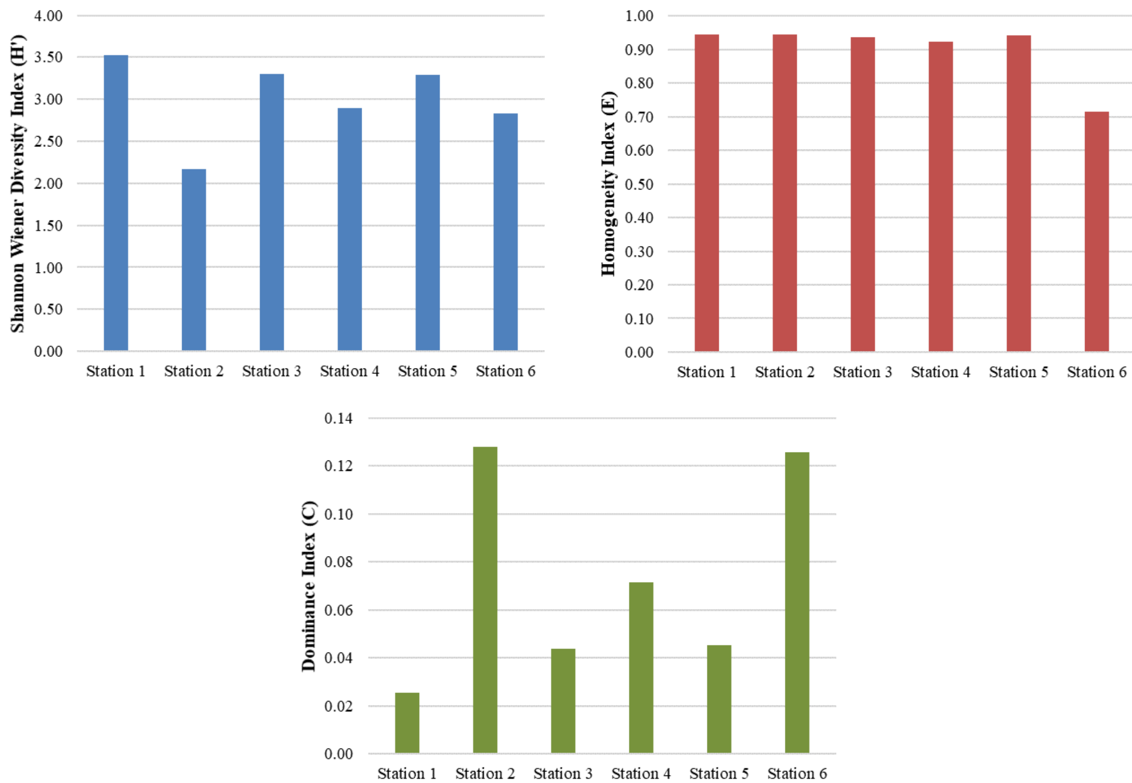


Fig. 7. Shanon Wiener Diversity index (H'), homogeneity index (E), and dominance index (C) at the six stations

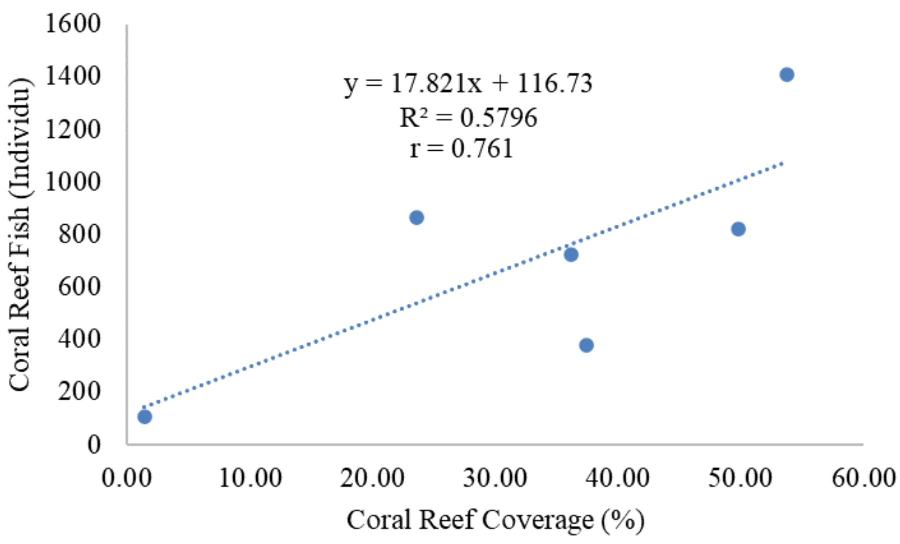


Fig. 8. Correlation of the number of coral reef fish with coral reef coverage

DISCUSSION

1. Biodiversity Habitat

The results of the present study indicate damage to coral reefs at all the observation stations, with the damage being most severe at stations 2 and 3. The causes of such damage are usually coral bleaching, environmental pressure, and human activities **(Toruan & Soedharma, 2013)**. Coral bleaching occurs due to the loss of part of a population of the symbiont algae Symbiodinium and the resulting white discoloration. Corals had lost 60–90% of their algal symbionts, and any remaining symbiont algae can lose 50–80% of their photosynthetic pigments **(Glynn, 1996)**. Coral reefs that experience bleaching can recover naturally when environmental stress is reduced. That is, when the environment is favorable for coral growth, symbiont algae are re-recruited by the coral. The presence of algae on dead coral at stations 1, 3, 4, 5, and 6 indicates that the coral reefs at these stations have started to recover. Additionally, the finding that hard coral cover was the main component of the coral reef ecosystem shows that coral reefs in the waters around Halang Melingkau Island are in good condition (except at station 2), as the percentage of coral cover is an indicator of recovery **(Berumen & Prachet, 2006).**

Station 2 had the highest non-living substrate cover (in the form of rubble) of all the upper-mentioned research stations. The coral fragments found were in *Acropora* foliose lifeforms. **Holmes *et al*. (2000)** have explained that rubble could be attributable to predation of organisms, disease, bioerosion, and unstable water conditions (extreme). Coral fragments are dynamic, shift easily, or moved by waves and currents. Therefore, it is difficult to distinguish between coral fragments arising from biological activities and fragments resulting from human activities **(Fox *et al*., 2003).**

The presence of axial corallite distinguishes *Acropora* corals from non-*Acropora* corals: *Acropora* corals have axial and radial corals, while non-*Acropora* corals do not have axial corals **(Suharsono, 2008).** In the present study, hardcoral lifeforms are found in *Acropora* and non-*Acropora*, which are reef builders, possessing different levels of sensitivity to different environmental pressures, and environmental factors, such as temperature, brightness, depth, and current strength, and the rate of sensitivity is contributed to the variation of influencing factors. Fluctuations in environmental conditions affect the growth rate, growth lifeform, and reproductive capacity of corals **(Kleypas *et al*., 1999)**, and this influences the abundance, composition, and diversity of coral communities **(Baker *et al*., 2008).** The composition of coral growth lifeforms at station 6 tends to be dominated by massive coral growth forms. Massive corals are known to be relatively more resistant to temperature stress than branching corals. Additionally, massive corals are known to have the ability to recover with a low death rate if they are bleached. Therefore, the dominance of massive coral lifeforms at station 6 indicates that hard coral at station 6 is more resistant to environmental stress and is not prone to damage..Of the various types of coral lifeforms, branched coral species are the most sensitive to changes in environmental temperature and can immediately recognize changes in temperature above normal or average conditions **(Rani, 2001).**

The differences observed in the coral cover across the six observation stations were thought to be influenced by the physical and chemical features of the waters as they are known limiting factors for the continuation and propagation of coral reefs **(Sabdono *et al*., 2014; Sekerci & Petrovskii, 2015; Faturohman *et al*., 2016; Harvey *et al*., 2018)**. If the physical-chemical parameters of waters do not meet the required criteria, it would have a negative impact on the survival of coral life either directly or indirectly **(Baum *et al*., 2015; Hoey *et al*., 2016; Saptarini *et al*., 2017; Khasanah *et al*., 2019)**. These results were in accordance with those reported by **Munasik and Siringoringo (2011), Iskandar and Tony (2013), Putri *et al*. (2015), Sahril (2017),** and **Nugraha *et al*. (2020)**, who also found that the cover of coral reefs in waters was influenced by the environmental features of the waters. The coral reef coverage, in turn, also influenced the surrounding environment, for example, the abundance of reef fish.

2. Coral Reef Fish Community Structure

Dartnall and Jones (1986), have classified reef fish into three main groups based on management objectives: target group (also known as economic fish), which are the main target of fishermen's catch; indicator group, which are considered as indicators of the coral condition; and the major group, which comprises fish between 5 and 25 cm in size that play an unknown role apart from their place in the food chain.

Pomacentridae is the dominant family in various places in the Indo-Pacific reef **(Coker *et al.*, 2013)**, and is also widely distributed in this region **(Satapoomin, 2000)**. Pomacentridae and Labridae families are part of the major fish groups that are always dominant in the Halang Melingkau Island waters. The Pomacentridae and Labridae families have also been reported to dominate the marine fish fauna of Redang Islands in Malaysia **(Du *et al.*, 2019).** Species of the Pomacentridae and Labridae families live on coral reefs throughout their life **(English *et al.*, 1997)**.

The Chaetodontidae family represents true coral reef fish. Its distribution is limited to coral reef ecosystems due to its dependence on coral reefs as food source **(Nugraha *et al.*, 2020)**. However, not all Chaetodontidae fish consume coral polyps as their primary food. Nonetheless, the existence and abundance of the Chaetodontidae family in waters can provide an overview on the condition of local coral reefs. **Manthacitra *et al*. (1991)** reported the presence of the Chaetodontidae family in the Gulf of Thailand. Similar findings were reported by **Lim and Chou (1991)** on Ghost Island and Raffles Light in Singapore while **Adrim (2011)** found that Chaetodontidae family was dominant on Bawean Island, Indonesia.

Station 6 showed the highest results in terms of total number or number of each category of fish. This may indicate that it was a more supportive environment than other stations. One of the main indicators may be coral reef coverage **(Duffy *et al.*, 2016; Basu & Mackey, 2018)**. Accordingly, Station 6 had a better coral reef cover than the other stations. This is consistent with **Karnan (2000)** observation that while reef fish are typically territorial in a coral ecosystem, habitat and environmental factors affect their presence in waters. That is, reef fish cannot withstand changes in the ecosystem, and such changes would lead to their migration to a more desirable spot. Thus, the presence of coral fish in an ecosystem is indicative of suitable ecological conditions.

Coral reef fish communities can be assessed through a number of indices, including the diversity index (H′), homogeneity index (E), and dominance index (C) of coral reef fish **(Prato *et al.*, 2017)**. A moderate diversity index indicates moderate environmental conditions (such as temperature, brightness, depth, and current strength) at a location. In this study, the lowest diversity index was found at station 2; thus, environmental pressure on the marine biota was very strong at this location **(Kultz, 2015)**. Coral reef fish diversity is influenced by several factors such as the physical-chemical conditions of the waters and the condition of the coral reef ecosystem that is the coral reef fish habitat. The level of diversity is categorized as high if the number of species and the number of individuals of each species are relatively evenly distributed **(Lehtonen *et al.*, 2016)**.

The homogeneity index was high at all stations observed. Meaningly, the community was stable at all six locations, as homogeneity index values above 0.6 indicate stability **(Messmer *et al.*, 2011)**. A low community homogeneity index value indicates the presence of species that dominate an ecosystem. Thus, a high homogeneity value indicates a stable community comprising similar or not very different types of species **(Pratchett *et al*., 2011)**.

The dominance index at all stations was low, as indicated by values below 0.5 **(Madduppa *et al*., 2012)**. The low dominance value is in agreement with the high homogeneity value observed. Additionally, the high dominance index values across station 2, station 4, and station 6 corresponded to low diversity index values at these stations. This result supports **Du *et al*. (2019)** stating that if the dominance value approaches 0, then the level of diversity in an ecosystem is higher, whereas if the dominance value approaches 1, then the diversity is lower.

3. Correlation of The Number of Coral Reef Fish with Coral Reef Coverage

Correlation analysis showed very strong correlation between the variable coral cover and coral fish abundance, as indicated by a correlation co-efficient value (r) of 0.761. Thus, the findings indicate that an increase in coral cover could lead to an increase in the abundance of reef fish, whereas a decrease in coral cover could lead to a decrease in the abundance of reef fish. This result coincides with the finding of **Komyakoova *et al*. (2018)**. In this context, station 6 had the highest coral cover and the highest abundance of reef fish, while station 2 had very low coral cover and the least abundance of fish.

The coral reef ecosystem is a crucial habitat for coral reef fish, which are dependent on the special structure and conditions of the coral reef biota **(Fenner, 2012)**. Furthermore, coral reef fish abundance and distribution are affected by the conditions and quality of the coral reef **(Songploy *et al*., 2017)**.

CONCLUSION

The findings of this research indicate that the coral reef ecosystem in Halang Melingkau Island, South Kalimantan, Indonesia, can be categorized as fair to good, with station 6 having the best coral coverage. These conditions are directly proportional to the abundance of reef fish communities at station 6, which also had the highest number of fish and the highest number of species. Thus, this finding confirms the strong positive correlation between coral cover and coral fish abundance: that is, a higher coral coverage in a location would lead to an increase in coral fish abundance in that area.

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REFERENCES

Adrim, M. (2011). The structure of reef fish communities on Bawean Island. In: "Biodiversity in the Bawean Island Water Region." Ruyitno, M.M.; Pramuji, S.; Susana, T. & Fahmi (Eds.). Research center for Oceanography-Indonesian Institute of Sciences, Jakarta, pp. 143-158.

Basu, S. and Mackey, K. R. M. (2018). Phytoplankton as key mediators of the biological carbon pump: their responses to a changing climate. Sustainability, 10 (869): 1-18.

Baker, A. C.; Glynn, P. W. and Riegl, B. (2008). Climate change and coral reef bleaching: an ecological assessment of long-term impacts, recovery trends and future outlook. Estuar. Coast. Mar. Sci., 80(4): 435-471.

Baum, G.; Januar, H. I. ; Ferse, S.C.A. and Kunzmann, A. (2015). Local and regional impacts of pollution on coral reefs along the thousand islands north of the Megacity Jakarta, Indonesia. PLoS ONE, 10(9): e0138271.

Berumen, M. L. and Pratchett, M. S. (2006). Recovery without resilience: persistent disturbance and long-term shifts in the structure of fish and coral communities at Tiahura Reef, Moorea. Coral Reefs. 25(4): 647-653.

Bozec, Y. M.; Yakob, L. ; Bejarano, S. and Mumby, P.J. (2013). Reciprocal facilitation and nonlinearity maintain habitat engineering on coral reefs. OIKOS, 122(3): 428-440.

Brower, J. E. and Zar, J. H. (1977). Field and laboratory method for general ecology. Wm. C Brown Publishing Dubuque. Iowa, 156pp.

Chong-Seng, K. M.; Mannering, T. D. ; Pratchett, M.S. ; Bellwood, D.R. and Graham, N.A. (2012). The influence of coral reef benthic condition on associated fish assemblages. PLoS One, 7(8): e42167.

Coker, D. J.; Wilson, S.K. and Pratchett, M.S. (2013). Importance of live coral habitat for reef fishes. Rev. Fish Biol. Fish., 24(1): 89-126.

Dahuri, R. (2000). Utilization of marine resources for community welfare. LIPI Jakarta, 145pp.

Dartnall, A. J. and Jones, M. (1986). A Manual of survey methods: living resources in coastal areas. asean-australia cooperative program on marine science handbook. The Australian Institute of Marine Science, Townsville, 167pp.

Du, J.; Loh, K. ; Hu, W. ; Zheng, X. ; Affendi, Y.A. ; Ooi, J.L.S. ; Ma, Z. ; Rizman-Idid, M. and Chan, A. A. (2019). An updated checklist of the marine fish fauna of Redang Islands, Malaysia. Biodivers. Data J., 7: e47537.

Duffy, J. E.; Lefcheck, J. S. ; Stuart-Smith, R.D. ; Navarrete, S.A. and Edgar, G.J. (2016). Biodiversity enhances reef fish biomass and resistance to climate change. Proc Natl Acad Sci USA,113(22): 6230–6235.

English, S. S.; Wilkinson, C. and Baker, V. V. (1994). Survey Manual for Tropical Marine Resources. ASEAN-Australia Marine Science Project Living Coastal Resources, Townsville, 368pp.

English, S. S.; Wilkinson, C. C. and Baker, V. V. (1997). Survey manual for tropical marine resources. Second ed. Australian Institute of Marine Science. Townsville, 390pp.

Faturohman, I.; Sunarto and Nurruhwati, I. (2016). The correlation of plankton abundance with sea water temperature at Cirebon steam electricity power station. Jurnal Perikanan Kelautan, VII(1): 115-122.

Fenner, D. (2012). Challenges for managing fisheries on diverse coral reefs. Diversity, 4: 105-160.

Fox, H. E.; Pet, J. S. ; Dahuri, R. and Caldwell, R.L. (2003). Recovery in rubble fields: long-term impacts of blast fishing. Mar. Pollut. Bull., 46(8): 1024-1031.

Friedlander, A. M. and Parrish, J. D. (1998). Habitatcharacteristics affecting fish assemblages on a Hawaiian coral reef. J. Exp. Mar. Biol. Ecol., 224(1): 1-30.

Glynn, P. W. (1996). Coral bleaching: facts, hypotheses and implications. Glob. Change Bio., 2(6): 495-509.

Gomez, E. D. and Yap, H. T. (1988). Monitoring reefcondition. Coral Reef Management Hand Book. Unesco Regional Office for South East Asia, Jakarta, 321pp.

Gratwicke, B. and Speight, M. R. (2005). The relationship between fish species richness, abundance and habitat complexity in a range of shallow tropical marine habitats. J. Fish Biol., 66(3): 650-667.

Harvey, B. J.; Nash, K. L. ; Blanchard, J.L. and Edwards, D.P. (2018). Ecosystem-based management of coral reefs under climate change. Ecol. Evol., 8(12): 6354-6368.

Hixon, M. A. and Beets, J. P. (1989). Shelter characteristics and caribbean fish assemblages: experiments with artificial reefs. Bull. Mar. Sci., 44(2): 666-680.

Hoey, A. S.; Howells, E. ; Johansen, J.L. and Hobbs, J.A. (2016). Recent advances in understanding the effects of climate change on coral reefs. Diversity, 8(12): 1-22.

Holmes, K. E.; Edinger, E.N. ; Hariyadi ; Limmon, G.V. and Risk, M.J. (2000) Bioerosion of live massive corals and branching coral rubble on Indonesian coral reefs. Mar. Pollut. Bull., 40(7): 606-617.

Ilham. (2007). The Relationship of Coral Reef Conditions and Rugosity with the Abundance and Diversity of Coral Fish in Badi Island, Pangkep Regency. Thesis. Department of Marine Science, Faculty of Fisheries and Marine Scinece, Universitas Hasanuddin, Makassar, Indonesia, 87pp.

Iskandar, R. and Tony, F. (2013). Sedimentation study at Angsana river in Angsana district, Tanah Bumbu regency, South Kalimantan. Enviro Scienteae, 9(2): 106-111.

Karnan. (2000). The Spatial-Temporal Association of Coral Communities with Coral Growth Forms in the Waters Southwest of the Island of Sumbawa, East Nusa Tenggara. Thesis. IPB University, Bogor, Indonesian, 92pp.

Kleypas, J. A.; McManus, J. W. and Meñez, L. A. B. (1999). Environmental limits to coral reef development: where do we draw the line? Am. Zool. 39(1): 146-159.

Kuiter, R. H. (1992). Tropical Reef Fish of Western Pacific. Indonesia and Adjacent Waters. PT. Gramedia Pustaka Utama, Jakarta, 314pp.

Kutner, M. H; Neter, J ; Nachtsheim, C.J. and Li, W. (2004). Applied linear statistical models. Fifth Edition. McGraw-Hill-Irwin, New York, 701pp.

Khasanah, R. I.; Herawati, E.Y. ; Hariati, A.M. ; Mahmudi, M. ; Sartimbul, A. ; Wiadnya, D.G.R. ; Asrial, E. ; Yudatomo and Nabil, E. (2019). Growth rate of *Acropora formosa* coralfragments transplanted on different composition of faba kerbstone artificial reef. Biodiversitas, 20(12): 3593-3598.

Komyakova, V.; Jones, G. P. and Munday, P. L. (2018). Strong effects of coral species on the diversity and structure of reef fish communities: a multi-scale analysis. PLoS ONE, 13(8): e0202206.

Kültz, D. (2015). Physiological mechanisms used by fish to cope with salinity stress. J. Exp. Biol., 218(12): 1907-1914.

Lehtonen, T. K.; Wong, B. B. M. and Kvarnemo, C. (2016). Effects of salinity on nest-building behaviour in a marine fish. BMC Ecol., 16(1): 1-9.

Levinton, J. S. (2013). Marine Biology: Function, Biodiversity, Ecology, fourth ed. Oxford University Press, Oxford, 530pp.

Lim, G. S. Y. and Chou, L. M. (1991). Studies of reef fish communities in Singapore. In: "Proceedings of The Regional Symposium on Living Resources in Coastal Areas." Alcala, A.C. (Eds.). University of the Philippines, Manila, pp. 319-328.

Luckhurst, B. and Luckhurst, K. (1978). Analysis of the influence of substrate variable on coral reef communities. Mar. Biol., 49: 317–323.

Madduppa, H. H.; Agus, S.B. ; Farhan, A.R. ; Suhendra, D. and Subhan, B. (2012). Fish biodiversity in coral reefs and lagoon at the Maratua Island, East Kalimantan. Biodiversitas, 13(3): 145-150.

Manthacitra, V.; Sudara, S. and Satumanapatpan, S. (1991). *Chaetodon octofasciatus* as indicator species for reef condition. In: "Proceedings of The Regional Symposium on Living Resources in Coastal Areas." Alcala, A.C. (Eds). University of the Philippines, Manila, pp. 596-613.

McElroy, J. L. (2006). Small island tourist economies across the life cycle. Asia Pac Viewp 47: 61-77.

Messmer, V.; Jones, G.P. ; Munday, P.L. ; Holbrook, S.J. ; Schmitt, R.J. and Brooks, A.J. (2011). Habitat biodiversity as a determinant of fish community structure on coral reefs. Ecol. 92(12): 2285-2298.

Minister of Environment of the Republic of Indonesia. (2001). Legislation in the Field of Environmental Management and Control of Environmental Impacts, Decree of the Minister of State No. 4 of 2001 concerning Standard Criteria for Marine Biota. Jakarta: Ministry of Environment. 26pp.

Munasik and Siringoringo, R. M. (2011). Hard coral community structure (Scleractinia) in Marabatuan and Matasirih Islands, South Kalimantan. Indon J Mar Sci 16(1): 14-21.

Nugraha, W. A.; Mubarak, F. ; Husaini, E. and Evendi, H. (2020). The correlation of coral reef cover and rugosity with coral reef fish density in East Java Waters. Jurnal Ilmiah Perikanan dan Kelautan 12(1): 131-139.

Pais, M. P. and Cabral, H. N. (2018). Effect of underwater visual survey methodology on bias and precision of fish counts: A simulation approach. PeerJ, 6(4), e5378.

Pratchett, M. S.; Hoey, A.S. ; Wilson, S.K. ; Messmer, V. and Graham, N.A. (2011). Changes in biodiversity and functioning of reef fish assemblages following coral bleaching and coral loss. Diversity, 3(3): 424-452.

Prato, G.; Thiriet, P. ; Di Franco, A. and Francour, P. (2017). Enhancing fish underwater visual census to move forward assessment of fish assemblages: An application in three Mediterranean Marine Protected Areas. PLoS ONE, 12(6): e0178511.

Putri, M. R.; Setiawan, A. and Safitri, M. (2015). Variation of ocean pH in the Indonesia waters. AIP Conf. Proc., 1677: 060021.

Rani, C. (2001). Coral Bleaching: Influences on the Coral Reef Communities. HAYATI, 8(3): 86-90.

Sabdono, A.; Radjasa, O.K. ; Ambariyanto, A. ; Trianto, A. ; Wijayanti, D.P. ; Pringgenies, D. and Munasik. (2014). An early evaluation of coral disease prevalence on Panjang Island, Java sea, Indonesia. Int. J. Zool. Res., 10(2): 20-29.

Sahril, A. 2017. Analysis of dissolved oxygen parameters in Southern Ocean island waters as an indicator of pollution in Kotabaru district. Research Report, Universitas Lambung Mangkurat, Banjarbaru, Indonesia. 34pp.

Saptarini, D.; Mukhtasor and Rumengan, I.F.M. (2017). Coral reef lifeform variation around power plant activity: Case study on coastal area of Paiton Power Plant, East Java, Indonesia. Biodiversitas 18(1): 116-120.

Satapoomin, U. (2000). A preliminary checklist of coral reef fishes of the Gulf of Thailand, South China Sea. Raffles B. Zool., 48(1): 31-53.

Sekerci, Y. and Petrovskii, S. (2015). Mathematical modelling of plankton–oxygen dynamics under the climate change. Bull. Math. Biol. 77(12): 2325-2353.

Songploy, S.; Chavanich, S. ; Kuanui, P. and Viyakarn, V. (2017). Diversity of reef fish at Royal Thai Naval Base, Sattahip, Chonburi Province, Thailand. Indian J. Geo Mar. Sci., 46(6): 1220-1225.

Suharsono. (2008). Types of coral in indonesia (Jenis-Jenis Karang di Indonesia). LIPI Press, Jakarta, 344pp.

Toruan, L. N. L. and Soedharma, D. (2013). The composition and distribution of benthic foraminifera at coral reef ecosystem in Kepulauan Seribu. Jurnal Ilmu Dan Teknologi Kelautan Tropis, 5(1): 1-16.